THE UNIVERSITY OF ALBERTA

GRAZING ANIMAL PREFERENCE OF CULTIVATED FORAGE SPECIES IN CENTRAL ALBERTA

By

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ABSTRACT

This study was initiated to evaluate the preference displayed by grazing steers for selected forages and to determine the relationship between this preference and forage quality. The study area was located in the east-central part of the Province of Alberta at Kinsella on the University of Alberta Ranch.

The forage species selected for this study included red top (*Agrostis alba* L.), crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), bromegrass (*Bromus inermis* Leyss.), Russian wild ryegrass (*Elymus junceus* Fisch.), creeping red fescue (*Festuca rubra* L.), birdsfoot trefoil (*Lotus corniculatus* L.), alfalfa (*Medicago media* Pers.), sainfoin (*Onobrychis viciaefolia* Scop.) and white clover (*Trifolium repens* L.). A forage mixture composed of bromegrass, creeping red fescue and alfalfa was included as a comparison with the pure forage stands.

Russian wild ryegrass was a preferred species in all growth stages. This was partially attributed to its high percent leaves and high percent moisture at maturity compared to other grass species. The animals utilized red top to a comparatively greater extent as it matured. Red top had a higher percent moisture content at maturity compared to most other grass species. Bromegrass was accepted and utilized by the steers throughout the grazing trial. Animal preference for creeping red fescue declined with maturity and the species was strongly avoided at

seed set. This leafy forage, at maturity, also showed a rapid decline in leaf protein which was considered an influencing factor in this avoidance behaviour. Low percent leaves, low percent moisture and high leaf crude fibre accounted for the decrease in animal acceptance of crested wheatgrass. The decline in animal preference for intermediate wheatgrass was attributed to low percent leaves, low percent moisture and low leaf acid-pepsin dry matter disappearance (A.P.D.M.D.). Birdsfoot trefoil was the most preferred legume after the vegetative growth stage. The reason for its popularity was not apparent in terms of the quality factors studied in this trial. Alfalfa was a productive, well utilized species, which had a high percent leaves. The leaves were high in protein and A.P.D.M.D. and low in crude fibre. White clover was avoided during the vegetative stage, possibly due to its low growth habit. As it matured, it became a preferred species which was attributed to its high percent moisture, observed leafiness and increased plant height. Sainfoin was avoided throughout the trial, but this trend could not be explained in terms of forage quality. The forage mixture produced more forage and was utilized to a greater extent than the pure forage stands. The preference shown by the grazing animals for the forage mixture was partially attributed to the variety offered in a localized area as opposed to the pure stands.

A preference rating based on the ratio of dietary composition to pasture composition was used to compare the cultivated forage species at different growth stages. Preference rating values greater than 1 indicated preference while values less than 1 indicated avoidance to a particular species. During the vegetative growth stage, intermediate wheatgrass, bromegrass, Russian wild ryegrass, creeping red fescue, alfalfa

and the forage mixture had preference rating values greater than 1. Red top, Russian wild ryegrass, birdsfoot trefoil, alfalfa, white clover and the forage mixture had values greater than 1 at the heading or flowering stage. Forages whose preference rating values exceeded 1 at maturity included red top, bromegrass, Russian wild ryegrass, birdsfoot trefoil, alfalfa, white clover and the forage mixture.

A regression equation was developed to evaluate the effect of various forage quality factors on the preference rating (Y) during each grazing period (vegetative, flowering and seed set). The first grazing period failed to yield a statistically significant regression equation. The relatively high quality of all species at this time would discourage selective grazing patterns based on forage quality. A significant linear regression equation was obtained during the second grazing period. A partial regression analysis indicated that percent leaves, stem crude fibre and stem A.P.D.M.D. had a positive influence on the preference rating during this period. Data collected when the forage was mature yielded a significant linear regression equation. The partial regression obtained from this analysis showed percent moisture as being the major positive influence on the preference rating.

Pasture utilization data was determined using three methods. The grazed versus ungrazed clipping technique was designated as the standard for comparison. It had high labour and equipment requirements. This method was valuable in determining the quantity of forage removed by an animal, but was subject to variability created by uneven animal distribution in the pasture. The esophageal fistula method presented the greatest difficulty in data collection and was found to be less suited to

this type of grazing trial than the other methods. The animals were in generally poor condition and under noticeable stress. Incomplete samples were observed and the chemical analysis of the fistula sample was affected by the loss of soluble material from the sample bags during collection. The bite count technique was not used to the same extent as the other methods. It was believed, however, that with proper modification this technique would be a simple, effective method of collecting pasture utilization data.

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INTRODUCTION

Grazing lands played a vital role in man's early existence. Before the domestication of livestock, he relied on the native forage to supply him with essential animal products. The transition of man from a food gathering nomad to a food producer signified the beginning of civilization. As a food producer, man developed pasture management techniques as an integral part of animal domestication. From these early beginnings developed the art and science of range and pasture management.

Animal nutrition has played an important role in grazing management. The importance of supplying an animal with the proper level of nutrition has been well established. Researchers have also determined the nutrient levels for many types of feed and forage (National Academy of Science, 1970). The ability of a grazing animal to select its optimum level of nutrition from a mixed sward is essential in maximizing animal production on pasture land (Meyer, Lofgreen and Hull, 1957).

When an animal chooses one forage species over another, the animal is said to have grazed selectively. The forage species grazed "first choice" are the preferred species (Kothermann, 1974). It is believed that an animal will ingest greater quantities of a preferred species, which has a definite effect on the animal's performance (Cowlishaw and Alder, 1960; Tribe, 1952). Smoliak (1968) studied the grazing inten-

sity and average daily gain of ewes on Russian wild ryegrass (*Elymus junceus* Fisch.) pastures, crested wheatgrass (*Agropyron cristatum* L.) pastures and native rangeland. It was shown that ewes grazed some species in preference to others and their preference changed during the six-month grazing period. It was also proven that ewes grazing a preferred species had a higher average daily gain as compared to ewes on less preferred species.

Animal preference is the result of variation in plant, animal and environmental factors. Workers have shown the physical and chemical make-up of forage to have a strong influence on the selective grazing behaviour of animals (Hardison *et. al*., 1954; Meyer *et. al*., 1956; Tribe, 1952). The condition of the sward has a definite effect on animal preference (Coleman and Barth, 1973; Johnstone-Wallace and Kennedy, 1944). In addition, there are many animal related factors such as age, health, condition, social environment and sensory perception. It is the combination of these factors that determines if a forage species will be accepted or rejected by a grazing animal.

Much of the research in the area of animal grazing preference has been conducted on native rangeland. Information regarding animal preference for the recommended tame forage species is limited. The first objective of this study was to determine the degree of selectivity an animal would exhibit when offered an assortment of palatable, cultivated forage. The species selected for this experiment were as follows:

red top (*Agrostis alba* L.)
crested wheatgrass (*Agropyron cristatum* L.)
intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.)
bromegrass (*Bromus inermis* Leyss.)

Russian wild ryegrass (Elymus junceus Fisch.)
creeping red fescue (Festuca rubra L.)
birdsfoot trefoil (Lotus corniculatus L.)
alfalfa (Medicago media Pers.)
sainfoin (Onobrychis viciaefolia Scop.)
white clover (Trifolium repens L.)

A plot containing a mixture of bromegrass, creeping red fescue and alfalfa was also included in each pasture. Canada No. 1 seed was used for all species. The forages were compared as to utilization and relative preference.

A second objective involved the analysis of each species for crude protein, crude fibre, relative digestibility, moisture content, leafiness and dry matter production. These factors were then compared with animal utilization to determine the relationship between forage quality and animal consumption. A regression equation was developed to evaluate the effect of the above mentioned factors on animal preference.

The primary method used to collect utilization data in this study was the grazed versus ungrazed clipping technique. In addition, the esophageal fistula and animal bite count techniques were also employed. They were compared to the clipping method to establish their usefulness in studies of this nature.

A stall feeding experiment was later carried out using confined animals. They were offered one legume species (alfalfa) and one grass species (bromegrass). The purpose of this trial was to determine if animals would exhibit selective behaviour when box-fed two different types of forage.

REVIEW OF THE LITERATURE

Animals eat for energy and when fed high-energy diets, energy intake regulates voluntary intake (Corbett, 1966). When animals are given low-energy diets such as pasture roughages, the rate of passage from the rumen or gut distention is the major factor governing voluntary intake (McClymont, 1967). Under suboptimal pasture conditions where the forage is unpalatable, unavailable or of poor quality, voluntary intake may be largely controlled by grazing fatigue caused by energy expended by the seeking and selection of more desirable forage species (McClymont, 1967).

In order for an animal to graze selectively, there must be available a variety of forage species in sufficient quantity to allow the animal to express his preference. If the forage becomes limiting, the self-imposed standards of palatability will diminish to the extent where an animal may consume material which is unpalatable, indigestible or even poisonous (Tribe, 1952). Arnold (1964) observed that as feed supplies decrease, an animal will compromise by eating previously neglected species, but will graze preferred species of low availability for a high portion of the total grazing time.

The selective preference shown for a forage species will be affected by the associated species in the plant community. Heady (1964) reported that some forage species were more heavily utilized when present in small quantities in good forage stands, but when grown in dense stands

the utilization was light. Hull and co-workers (1957) and Smoliak (1969) found that the forage intake of animals on pasture was related to the kinds of forage offered, however, Hardison and co-workers (1954) found no correlation between the degree of forage selection and dry matter intake.

Physical characteristics such as hairiness, spines, harshness, toughness and stickiness reduced forage palatability (Beaumont, 1933; Davies, 1925; Heady, 1964). Plant growth habit affected selectivity by influencing availability as in the case of prostrate growing plants (Jones, 1933). Grazing animals exhibited greater selectivity with tall, sparse forage than with low, dense forage, while short forage plants (10 to 12 centimetres) were preferred over taller forage, possibly because the animals were conditioned in the knowledge that the tall forage was more stemmy and fibrous (Johnstone-Wallace and Kennedy, 1944; Meyer et. al., 1957).

Environmental factors have an effect on the acceptability of a forage plant to an animal. Schneider-Kleeberg (1932) reported the water table and the aspect of the land as being influencial in plant palatability. He observed cattle grazing more where the sun had lain longest. Soil type and fertility also influenced palatability and selection (Stapledon, 1934). Jones (1952) concluded that soil factors such as poor drainage, low pH and lack of necessary plant nutrients would generally reduce palatability. He also mentioned frost damage as reducing palatability.

Animals selected for plant parts as well as plant species (Jensen et. al., 1964). Jones (1952) stated that young leaves, being

more succulent than stems, were more palatable to the grazing animal and therefore, forage intake was greater with a high ratio of leaves to stems.

Lofgreen and Meyers (1956) observed that animals grazing mature forage were more selective grazers than those on immature forage. This was believed to be an effort by the animal to seek out young succulent material in more mature forage. Jones (1952) reported that cattle grazing two strains of ryegrass, selected the early maturing strain first, but three weeks later concentrated on the later maturing strain even though the early strain was still in leafy condition.

It has been generally accepted that grazing animals, if given a choice, would select a diet of higher nutritive quality than the average analysis of the available forage. Nutrient deficiencies are often associated with a reduced feed intake (McClymont, 1967). When offered a variety of forage, grazing animals were able to hold the nutrient level of their diets constant by shifting grazing from species to species (Edlefsen, et. al., 1960).

It has been reported that the diet of steers grazing tame pastures was 23.3 percent higher in crude protein than the whole available herbage (Hardison et. al., 1954). Similar findings were reported in studies involving sheep and cattle on tame and native pasture (Rama Rao et. al., 1973 and Weir and Torell, 1959). Milford and Minson (1966) found no correlation between crude protein and voluntary intake, the possible reason being that the protein levels of the forage used in this study were adequate to satisfy the needs of the animal.

Crude fibre values have been found to be as much as 16.8 per-

cent less in the actual diet of grazing steers than was available in the pasture (Hardison et. al., 1954; Fontenot and Blaser, 1965; Coleman and Barth, 1973). Crampton (1957) reported crude fibre as not being significantly correlated to voluntary consumption.

In a grazing study using sheep, Blaxter et. al. (1961), reported that intake was dependent on the rate of passage of fodder through the animal's digestive tract and therefore, concluded that voluntary intake was closely associated with the digestibility of the feed. There was further evidence which showed that grazing animals selected a diet consistently more digestible than the whole herbage (Hardison et. al., 1954).

Other chemical components of plants that increased palatability included a high sugar content (Plice, 1952), high total ether extract (Hardison et. al., 1954), high levels of phosphate and potash (Leigh, 1961) and an increased fat content (Blaser et. al., 1960). Certain antiquality plant components decreased animal acceptance and these included varying levels of tannins and phenols (Burns et. al., 1972), high saponin levels (Hanson et. al., 1973), high alkaloid concentration (Marten, 1973) and the amount of volatile oils (Smith, 1950). Voigt (1975) suggested that when these antiquality components were not present, there was often little relationship between palatability and animal performance unless the palatability difference was very large.

Van Soest (1965) reported that lignin, acid-detergent fibre, protein, cellulose, cell-wall constituents and digestibility were highly correlated to voluntary intake in three grass species while no correlation was found in four other species. High species variation made intake

predictions using chemical factors very unreliable.

The palatability of a forage species has been dependent on behavioural and physical characteristics of the grazing animal. Different types of animals prefer different food as was demonstrated by the classical study of Linnaeus in which he offered many different plants to sheep, cattle, goats, horses and pigs and found that plant species, readily eaten by one type of animal, may be neglected by other types of animals (Tribe, 1952). A more recent study reported variations of up to 20 percent on native rangeland, between sheep and cattle intake per unit liveweight (Van Dyne and Meyer, 1964). Variation is evident within the same class of livestock due to the individuality of each animal regarding forage preference and degree of selectivity. Larkin (1954) observed variations in animal activity for one day of up to three hours 46 minutes grazing, four hours 23 minutes loafing and two hours 34 minutes lying down. Variations in forage preference have been reported (Heady and Torell, 1959) while other workers (Van Dyne and Meyer, 1964) reported high variability among sheep but not cattle.

The age and condition of the grazing animal have been closely related to intake and selectivity. Once young animals have outgrown the inquisitive stage, they become more selective and generally eat the more palatable plant parts and plant species (Jones, 1952). Animals in good condition grazed selectively but as the need for food increased, selectivity decreased and intake increased (Arnold, 1970). Lactating or pregnant cows have greater feed demands and would have a higher intake and possibly lower selectivity (Arnold and Dudzinski, 1967; Cook _et. al._, 1961). Intake was greater in high producing or rapidly growing

animals, however, selectivity would decrease as pasture condition declines (Corbett et. al., 1963). Sickness would result in lower food intake and often reduced appetite was the first symptom of an animal health disorder (Tribe, 1952).

The intake rate and degree of selectivity of a grazing animal has been influenced by the environment. Dwyer (1961) found that when the air temperature exceeded 29.4° C, grazing time and food intake was reduced and the cows made no effort to increase intake in the cool evening grazing period to compensate for grazing time lost during the hot day. If temperatures were high enough to make an animal uncomfortable, it would graze just slightly more than required to satisfy its basic requirements. McClymont (1967) suggested that heat stress is usually associated with nutritional and disease stress and it is difficult to determine the effect of temperature on the grazing animal. Other studies (Sheppard et. al., 1957) failed to show any relationship between maximum and minimum daily temperatures and the grazing behaviour of beef cattle. Sheep that were subject to cold temperatures following shearing increased food intake 40 to 60 percent (Wheeler et. al., 1963), however, cold-wet weather produced a drastic reduction in intake with sheep on poor pasture after shearing (Arnold, 1970).

Grazing behaviour has been influenced by the animal's social environment and psychological conditioning. Tribe (1950) reported sheep on poor pasture would stimulate supplementally-fed sheep to graze longer. In another study (Holder, 1962), sheep on good pasture and supplementation reduced the grazing time and forage intake of unfed sheep grazing in a common pasture. Social pressure such as being low in the peck order

has reduced intake and animal performance. The effect of preconditioning on an animal's grazing behaviour is illustrated by Arnold's (1970) findings that sheep grazing in pastures and environments in which they had no previous experience, reduced intake by 50 percent for as long as 10 months. Cowlishaw and Alder (1960) also reported the importance of the animal's previous history and the environment of the herbage on offer to it, as related to the animal's grazing habits. This learned behaviour may change as food that is ignored when first introduced into the diet may later be selected over other feeds by the animal (Jones, 1952). Grazing animals would tire of a particular diet and selectively graze new plant species (Tribe, 1952) or species that required less effort to collect (Johnstone-Wallace and Kennedy, 1944). Any external factor which would cause psychological stress could also affect an animal's grazing behaviour. McClymont (1967) sited animal population density, presence of predators and pain from infective disease of the feet or mouth as being psychic stress factors which could affect animal performance.

Forage selectivity is influenced by the animal's sensory perceptions. This relationship between the senses and selectivity was found to be complex with specific senses interacting with other senses (Krueger et. al., 1974). Taste appeared to be the most important sensory component and the most extensively studied in hopes of manipulating animal preference (Baile and Martin, 1972; Goatcher and Church, 1970; Krueger et. al., 1974). The four primary tastes in ascending order from most stimulatory to least were: bitter, sour, salty and sweet (Goatcher and Church, 1970). It has long been suspected that cattle and sheep are colour blind (Tribe and Gordon, 1949), however, Beck (1975) observed that

cattle showed a preference for dark-green plants over yellow-green plants. Cattle have been shown to differentiate plant growth forms in a selective manner (Krueger _et_. _al_., 1974). An animal's aversion to manure-fouled plants illustrated the importance of the sense of smell in selective grazing behaviour. If an animal was in close contact with a particular odour, it would soon lose the power to detect the smell and could only detect unfamiliar odours (Tribe, 1949). Other workers have observed the importance of smell related to the selection of plant parts (Arnold, 1966) and initial forage selection (Longhurst and Kepner, 1968). The coarseness, hairiness, prickliness, etc., may affect an animal's sense of touch. This sense was reported to be supplementary to the sense of taste in the selection of plant species (Krueger _et_. _al_., 1974). Among strains of one plant species, the preference ranking would be determined by several senses and rarely determined by a response to a single sense (Arnold, 1970).

THE STUDY AREA

This study was conducted at the University of Alberta Ranch, located at Kinsella, Alberta, in the northwest quarter of section 16, township 47, range 11, west of the fourth meridian. This area is situated in the thin black soil zone of Alberta and is classified as a glacial loam of the Viking moraine (Wyatt _et_. _al_., 1944).

Topographically, the area is rolling to hilly and is described as a knob and kettle moraine with sloughs in the depressional areas. The northerly portion of the plot area was situated on a south-facing slope which gradually formed a depression in the south-central region.

The native vegetation was typical of the parkland type with _Populus tremuloides_ being the dominant woody species and _Festuca scabrella_ and _Stipa spartea_ var. _curtiseta_ being the dominant grass species (Smoliak _et_. _al_., 1974). The depressional areas were dominated by numerous species of _Carex_ and _Juncus_.

The mean annual precipitation in this area (1931 - 1960) was 40.6 centimetres with the maximum precipitation between July 1st and July 15th (Wonders, 1969). Moisture and temperature conditions during the summer of 1973 are summarized in Table 1.

The temperature ranges from an average monthly maximum of 23.9° C in July to an average monthly minimum of -20.6° C in January (Wonders, 1969). The frost-free period of this region averages 100 days with the first fall frost usually occurring in the early part of Septem-

TABLE 1. The mean monthly temperature and rainfall in the Kinsella area for the summer period of 1973. (Atmospheric Environmental Service, Environment Canada, 1973).

	MONTHS				
	May	June	July	August	September
Total Rainfall (centimetres)	1.02	20.19	8.94	14.02	3.63
Maximum Temperature (degrees C.)	28.90	31.70	30.00	27.2	25.00
Minimum Temperature (degrees C.)	-3.30	2.20	5.60	-0.60	-4.40
Mean Temperature (degrees C.)	11.70	14.40	16.10	16.00	10.00

ber and the last spring frost usually occurring in the latter part of May (Wonders, 1969).

MATERIALS AND METHODS

A. Plot Design

Ten common Alberta forage species and one recommended forage mixture were sown on May 31, 1972 and June 2, 1972, in strips, 3.5 meters wide and 45.7 meters long at the rate and row spacing listed in Table 2. The study area is illustrated in the colour infra-red photograph (Figure 1).

Figure 1. A colour infra-red aerial photograph of the study area.

Weed infestations were severe during the first year and the area required raking in the spring of 1973 to remove the litter. Three separate pastures were established, each containing four replications of each forage species and the mixture. Forage establishment and growth were generally good but varied within and between plots. The outer 7.6

TABLE 2. Seeding rates and drill run spacing used for establishment of 10 forages and the forage mixture (Kinsella, 1973).

SPECIES	SEEDING RATE (kg/ha)	DRILL RUN SPACING (cm)
Red Top	10.1	17.8
Crested Wheatgrass	11.2	17.8
Intermediate Wheatgrass	9.0	17.8
Bromegrass	6.7	17.8
Russian Wild Ryegrass	5.6	35.6
Creeping Red Fescue	9.0	17.8
Birdsfoot Trefoil	12.3	17.8
Alfalfa	6.7	17.8
Sainfoin	20.2	17.8
White Clover	7.8	17.8
Forage Mixture[1/]	13.4	17.8

[1/] Forage Mixture - Alfalfa (2.24 kg/ha), Creeping Red Fescue (4.48 kg/ha) and Bromegrass (6.72 kg/ha).

meters in pasture number one and 15.2 meters in pastures number two and three were fenced to form exclosures. Details of the experimental layout are shown in Appendix 2 and 3.

B. Grazing Animal Preference Trial Conducted at Kinsella

1. Forage preference study using grazed versus ungrazed clipping technique

Four fistulated steers were allowed to graze one of three pastures at different plant growth periods throughout the summer. Pasture number one was grazed from May 31 to June 17 beginning when the forage was 15 centimetres tall and ending when the majority of forage species was heading or flowering. This was referred to as the "first grazing period". Pasture number two was grazed from June 21 to July 10 beginning when the forage was heading or flowering and ending when most species were setting seed. This was the "second grazing period". The "third grazing period", conducted in pasture number three, began when most forage plants had set seed (July 11) and was completed July 31.

During each grazing period, one-half meter plots in the pasture being utilized were clipped at ground level prior to grazing, midway through the grazing period and at the end of the grazing period. Samples taken were relatively weed free. The first two clippings were used to check plant growth during the grazing period, but were not included in the statistical analysis. Plant height and plant maturity data is available in Appendix 1. Each replicate of the 10 forage species and the mixture was sampled by clipping two one-half meter plots in each grazed and exclosed forage strip in the pasture. After drying the samples at

65° C, the dry weight was recorded.

Production was the quantity of a forage species available to the grazing animal during each grazing period as determined by the dry weight of clipped samples taken at the end of each period in the exclosed area. Utilization was the dry weight difference between a forage clipping taken at the end of each grazing period within the grazed area and the weight from the corresponding plot in the exclosure. Four means were analyzed using the least significant difference technique. Grasses and legumes were then analyzed in two groups rather than by species and the results were compared by the least significant difference technique and unpaired T test.

A preference rating was used to compare the relative preference exhibited by the steers for the various forage species (Van Dyne and Heady, 1965 and Rosiere _et_. _al_., 1975). To obtain the preference rating, the utilization of each species expressed as a percentage of total pasture utilization was divided by the production of each species expressed as a percentage of total pasture production. Preference rating values greater than 1.0 indicated preference while values less than 1.0 indicated avoidance.

The percent utilization was calculated by dividing the utilization of each species (Kg/ha) during each grazing period by the production (Kg/ha) of that species for that particular period. The data was subject to an arc sin transformation and analyzed using the least significant difference technique.

Midway through each grazing period, a random sample of each forage species was clipped from the exclosed area of the pasture being

actively grazed. Samples were dried at 95° C and leaves and stems of each species were separated and individually weighed and analyzed for protein, crude fibre and acid-pepsin dry matter disappearance (A.P.D.M.D.).

Crude protein was determined using a Coleman nitrogen analyzer (Stewart et. al., 1963). The samples were ground to pass through a 100-mesh screen and 10 milligrams were placed in the centre of a combustion tube with CuO packed on each side. The tube was then positioned and the nitrogen analyzer began the combustion cycle. The first stage of this cycle was the purge in which CO_2 passed through the tube to replace any N_2 present. The sample then went through a preheat, first combustion and final combustion stage in which temperatures reached 900° C. This was followed by a sweep stage in which CO_2 carried the N_2 present. The crude protein content was then calculated. Each sample was analyzed twice and percent crude protein was recorded. The production from each forage strip was multiplied by the percent crude protein of the species to determine protein production per hectare. This data was tested by the least significant difference method.

The acid-detergent fibre method was used to determine the fibre content of the samples (Van Soest, 1963). Throughout the text, the phrase, "crude fibre content", is used to indicate the values obtained by the acid-detergent fibre method. The sample was ground to pass through a 30-mesh screen and one gram was placed into a beaker. One hundred millilitres of acid-detergent solution (sulfuric acid and cetyl trimethyl-ammonium bromide) plus two millilitres of decahydronaphthaline were added and heated to boiling and refluxed 60 minutes. The sample was then fil-

tered in a crucible, rinsed with water and acetone, dried at 100° C for eight hours and weighed. The acid-detergent fibre was calculated using the formula, $\frac{(Wo - Wt)\ (100)}{S}$ = ADF, where Wo is the crucible weight plus fibre, Wt is the tared weight of the crucible and S is the dried sample weight. Crude fibre per hectare was calculated by multiplying the production per hectare by the percent crude fibre. Each sample was analyzed twice and this data was tested by the least significant difference method.

The acid-pepsin dry matter disappearance (A.P.D.M.D.) technique was used as an indicator of species digestibility (Donefer _et_. _al_., 1966; Kendall _et_. _al_., 1970; Sleper _et_. _al_., 1973). Each sample was ground to pass through a 30-mesh screen and one gram was placed in a flask. Seventy-five millilitres of acid-pepsin solution (two percent pepsin and 0.075 N HCl) were added. The flasks were stoppered and agitated in a constant waterbath at 40° C for 24 hours. The samples were then filtered in glass crucibles under suction and oven dried. The percentage of dry matter removed from the sample was then calculated by subtracting the weight of forage residue from the initial forage weight and expressing this as a percentage. Each sample was analyzed twice and the data was tested with the least significant difference method.

2. Forage preference study using esophageal fistula collection technique

Of the four steers used in the experiment, two were sampled at various intervals using the esophageal fistula and two were unsuitable for sampling but were grazed with the other steers to provide a calming influence during sampling and to provide the necessary grazing pressure

for the grazed versus ungrazed clipping study. During each grazing period, the two steers were sampled morning and evening for 10 days. All four animals were penned without water or feed the night prior to sampling.

Sampling involved removal of the split-plug stoppers from the esophageal fistula, securing a collection bag around the animal's neck (Figures 2, 3 and 4), attaching a 30.5 meter rope to the halter and releasing all four steers into the pasture to be sampled (Harris _et_. _al_., 1967; Torell, 1954; Van Dyne and Torell, 1964). Collection time varied from 15 to 20 minutes, depending on the forage intake rate. When the collection was completed, the sampling steers were captured, the collection bag and lead rope removed and the split-plug stoppers inserted into the esophageal fistula to allow the animal to graze normally. After the morning sampling, the four animals were allowed to graze in the pasture under study until noon when they were again penned until the evening sampling. The same procedure was followed in the evening except the steers were only allowed one-half hour of normal grazing after sampling before being penned for the night. The animals were normally sampled three days per week and were allowed to graze freely in the pasture under study on non-sampling days. Animal health problems during the third grazing period made it necessary to use different sampling animals.

Fistula samples were rinsed with water immediately after sampling to facilitate species identification. The samples were then placed in plastic bags and transported to the lab where each sample was mixed thoroughly before taking random grab samples. A 500-gram sample was placed on a tray and oven dried at 95° C and later analyzed for nitrogen,

Figure 2. Fistulated steer showing split-plug stoppers installed in esophagus.

Figure 3. Fistulated steer showing split-plug stoppers removed for sampling.

Figure 4. Fistulated steer showing collection apparatus.

crude fibre and A.P.D.M.D. using the techniques previously described. The results of this quality analysis were then compared with calculated values obtained by multiplying the percent value of each quality factor by its percent composition in the fistula sample. This was repeated for leaves, stems and whole plants (based on leaf-stem ratios). Four means were analyzed using the least significant difference technique.

A 200-gram sample was washed with water, using a 30-mesh screen and 25-gram samples were placed in two trays with perforated bottoms. Water was added to the trays until the sample could be dispersed evenly in the tray. The water in the tray was allowed to drain and the sample was examined under a 10-power binocular microscope to determine the species composition (Harker _et_. _al_., 1964). Four lengthwise transects were studied on each tray with all forage leaf particles greater than 0.5 centimetres in length being identified (Figure 5). The legumes were

Figure 5. Apparatus used to determine species composition of fistula samples.

easily identified by leaf shape and leaf margin variations. Creeping red fescue and Russian wild ryegrass were readily identified by leaf shape and colour. Red top, bromegrass, intermediate wheatgrass and crested wheatgrass were difficult to differentiate and careful study of texture, colour and leaf size was necessary. A bite count, taken at the time of sampling, was often used to determine which forage species would be present in any given sample. Four means were analyzed using the least significant difference method.

3. Forage preference study using the bite count technique

During the time the steers were sampled using the esophageal fistula, a bite count was recorded on the two sampling animals (Dwyer, 1961). The bite count involved recording the number of mouthfuls each steer took of each forage species. It was difficult to determine the

bite count on some tall grass species during the third grazing period, due to poor visibility. Four means were used in the statistical comparison of the species using the least significant difference method.

4. Statistical evaluation of the preference rating

The various chemical and physical forage characteristics were compared to animal utilization and the preference rating using the program, "Factor Analysis using Hotelling's Method", developed by D. Precht for use of the IBM 360. Further analysis was conducted using G. Grobbin's program for stepwise multiple regression for which partial regressions were obtained for testing the effect of influencial quality factors on the preference rating.

C. Preferential Grazing Behaviour Patterns Exhibited By Esophageal Fistulated Steers

Following the first grazing period, pasture number one was mowed, leaving a six-centimetre stubble height on all species in the grazed area of the pasture. On August 2, when the species had grown 30 to 40 centimetres in height, six esophageal fistulated steers were allowed to graze this area. The steers were sampled in pairs each evening for five days, using the collection techniques previously mentioned. The bite count was recorded for each animal during the sampling period. Following collection, the samples were rinsed with water, bagged, labelled and transported to the lab where the species composition of each sample was determined, again using the binocular microscope technique. Six means were analyzed by the least significant difference technique to test

differences between species.

D. Confined Animal Forage Preference Study Conducted At Parkland Farm At The University Of Alberta

Eight steers were hand fed fresh-cut alfalfa and bromegrass, each day for four days. The animals were confined in two pens with four steers in each. The forage was placed in 20 centimetre by 60 centimetre feed boxes and two boxes of each species were placed in each pen. The forage in each box was weighed prior to feeding. The average weight of forage remaining after feeding was 19.9 kilograms. The forage was weighed after approximately one-half hour of feeding. Before and after each feeding period, a 300-gram sample of both types of forage was collected and dried at 65° C. The dried samples were then weighed to determine the moisture content of the forage and the moisture loss during each feeding trial. The data was analyzed as a randomized block design.

RESULTS

A. Grazing Animal Preference Studies

1. Forage preference study using grazed versus ungrazed clipping technique

The grazed versus ungrazed clipping method of determining utilization was designated as the standard because of its simplicity and general acceptance in the scientific community. This provided the basis of comparison with the other utilization techniques employed in the study.

The 1973 moisture conditions were not normal for this area. There was low precipitation in April, May and July and high precipitation in June and August. In spite of the dry spring conditions, no forage species became unavailable to the grazing animal at any time during the trial.

(a) Animal utilization of available forage

Red top, Russian wild ryegrass, alfalfa and the forage mixture increased in production significantly between the first and third period (Table 3). Russian wild ryegrass produced the least forage of any species for each grazing period. Creeping red fescue and intermediate wheatgrass were the highest producing forages during the first grazing period and significantly out-yielded all species except bromegrass and the forage mixture. In the second grazing period, the highest producing forage, intermediate wheatgrass, produced significantly more forage than crested wheatgrass, Russian wild ryegrass, sainfoin and white clover.

TABLE 3. Production of 10 forages and a forage mixture from the dry weight of samples clipped at the end of each grazing period (Kinsella, 1973).

Species	PRODUCTION (kg/ha) (n = 4) Grazing Period 1	2	3	Mean	LSD[1/] (0.05)	(0.01)
Red Top	1,263	4,078	6,325	3,888	1,821	2,757
Crested Wheatgrass	1,553	3,140	4,165	2,953	NS[2/]	NS
Intermediate Wheatgrass	2,865	6,158	5,755	4,926	NS	NS
Bromegrass	2,323	5,703	6,140	4,722	NS	NS
Russian Wild Ryegrass	645	793	1,583	1,007	766	NS
Creeping Red Fescue	2,898	5,128	5,193	4,406	NS	NS
Birdsfoot Trefoil	828	5,265	4,360	3,484	NS	NS
Alfalfa	1,695	4,373	7,675	4,581	2,675	4,051
Sainfoin	1,635	3,325	4,172	3,044	NS	NS
White Clover	1,015	3,678	6,253	3,648	NS	NS
Forage Mixture	2,318	5,775	8,303	5,465	2,913	4,411
Mean (kg/ha)	1,731	4,311	5,448			
LSD (0.05)	835	2,115	3,376			
LSD (0.01)	1,125	2,851	4,551			

1/ Least significant difference at the 0.05 and 0.01 levels refer to differences in kg/ha production values.

2/ Non significant F value at the indicated level.

The forage mixture was the highest producer in the third period, being significantly superior to crested wheatgrass, Russian wild ryegrass, birdsfoot trefoil and sainfoin.

Red top was the only species to increase significantly in animal utilization, from the first through the third grazing period, while creeping red fescue showed a significant decrease in utilization during that time (Table 4). The most utilized forage species during the first period was intermediate wheatgrass in contrast to white clover, which was almost unused. During the second period, birdsfoot trefoil was the most utilized forage, but not significantly greater than bromegrass, alfalfa and the forage mixture. The forage mixture appeared to be the top choice in the third grazing period, being significantly more utilized than Russian wild ryegrass and sainfoin as well as crested wheatgrass, intermediate wheatgrass and creeping red fescue, which were unutilized or nearly so.

During the first grazing period, animal utilization and forage production ($r = 0.918$) were closely related (Table 6), however, this relationship was not evident in the second and third grazing periods (Tables 7 and 8). The preference rating (Table 4) was based on the ratio of forage production to the degree of utilization by the grazing animal. During the first grazing period, the preference rating showed the steers exhibited an avoidance to red top, crested wheatgrass, birdsfoot trefoil and sainfoin and a strong avoidance to white clover. A slight preference was shown for intermediate wheatgrass, bromegrass, Russian wild ryegrass, creeping red fescue, alfalfa and the forage mixture. Other species were grazed to the same percentage as was produced in the pasture. During the

TABLE 4. Utilization of 10 forages and a forage mixture based on the dry weight difference in clipped samples taken in grazed and enclosed areas at the completion of each grazing period (Kinsella, 1973).

Species	UTILIZATION (kg/ha) (n = 4)				LSD[1]	
	Grazing Period			Mean	(0.05)	(0.01)
	1	2	3			
Red Top	$533_{0.9}$[3]	$2,058_{1.1}$	$3,495_{1.5}$	2,028	1,732	NS[2]
Crested Wheatgrass	$560_{0.8}$	$338_{0.2}$	$-120_{0.0}$	259	NS	NS
Intermediate Wheatgrass	$1,563_{1.2}$	$685_{0.2}$	$42_{0.0}$	763	NS	NS
Bromegrass	$1,323_{1.2}$	$2,843_{1.0}$	$2,805_{1.2}$	2,323	NS	NS
Russian Wild Ryegrass	$348_{1.2}$	$723_{1.9}$	$1,000_{1.7}$	690	NS	NS
Creeping Red Fescue	$1,400_{1.1}$	$1,508_{0.6}$	$-770_{0.0}$	713	1,659	NS
Birdsfoot Trefoil	$345_{0.9}$	$4,625_{1.8}$	$3,055_{1.9}$	2,675	NS	NS
Alfalfa	$980_{1.3}$	$3,263_{1.5}$	$3,733_{1.3}$	2,658	NS	NS
Sainfoin	$378_{0.5}$	$1,060_{0.7}$	$1,203_{0.8}$	880	NS	NS
White Clover	$20_{0.0}$	$2,218_{1.2}$	$3,765_{1.6}$	2,001	NS	NS
Forage Mixture	$1,323_{1.2}$	$3,638_{1.3}$	$4,233_{1.4}$	3,064	NS	NS
Mean	797	2,087	2,040			
LSD (0.05)	939	2,253	2,764			
LSD (0.01)	NS	3,037	3,725			

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non significant F value at the indicated level.

3/ Relative preference ratings exhibited by steers for forages. Values greater than 1.0 indicate preference and values less than 1.0 indicate avoidance.

TABLE 5. Percent utilization of 10 forages and a forage mixture obtained from production values (Table 3) and utilization values (Table 4), (Kinsella, 1973).

Species	Percent Utilization[1/] (n = 4)			LSD[2/]	
	Grazing Period			(0.05)	(0.01)
	1	2	3		
Red Top	42	51	55	NS[3/]	NS
Crested Wheatgrass	36	11	0[4/]	18.7	28.3
Intermediate Wheatgrass	55	11	0	39.6	NS
Bromegrass	57	50	46	NS	NS
Russian Wild Ryegrass	54	91	63	NS	NS
Creeping Red Fescue	48	29	0	25.0	37.8
Birdsfoot Trefoil	40	88	70	44.6	NS
Alfalfa	58	75	49	NS	NS
Sainfoin	23	32	29	NS	NS
White Clover	2	60	60	31.3	47.4
Forage Mixture	57	63	51	NS	NS
LSD (0.05)	30.1	25.6	25.7		
LSD (0.01)	41.0	33.5	35.1		

1/ Data was subject to Arc Sin transformation prior to analysis.

2/ Least significant difference at the 0.05 and 0.01 levels.

3/ Non significant F value at the indicated level.

4/ Negative utilization values (Table 4) were regarded as experimental error and were assigned a 0 percent utilization value in this table.

TABLE 6. Correlation coefficient matrix for chemical and physical characteristics of the 10 forage species and animal utilization and preference during the First Grazing Period (n = 10). Trifolium repens was not included in the statistical analysis of stems (Kinsella, 1973).

	1 Pref.	2 Percent Prod.	3 Percent Util. Clipping	4 Percent Util. Fistula	5 Percent Util. Bite Count	6 Percent Moisture	7 Percent Leaves	8 Protein Prod.	9 Crude Fibre Prod.	10 Leaf Protein	11 Leaf Crude Fibre	12 Leaf A.P.D.M.D.	13 Stem Protein	14 Stem Crude Fibre	15 Stem A.P.D.M.D.
1	1.000														
2	NS	1.000													
3	0.647*	0.918**	1.000												
4	NS	0.930**	0.835**	1.000											
5	NS	0.809**	0.639*	0.940**	1.000										
6	NS	NS	NS	NS	NS	1.000									
7	NS	NS	NS	NS	NS	NS	1.000								
8	NS	0.949**	0.844**	0.929**	0.866**	NS	NS	1.000							
9	NS	0.926**	0.835**	0.940**	0.863**	NS	-0.630*	0.934**	1.000						
10	NS	-0.653*	NS	NS	NS	NS	NS	NS	NS	1.000					
11	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.000				
12	NS	NS	NS	NS	NS	0.696*	NS	NS	-0.630*	0.783**	-0.819**	1.000			
13	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.000		
14	NS	NS	NS	NS	NS	0.719*	NS	NS	NS	NS	NS	NS	NS	1.000	
15	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.000

Pref. = Preference
Prod. = Production
Util. = Utilization
NS = Non Significant

TABLE 7. Correlation coefficient matrix for chemical and physical characteristics of the 10 forage species and animal utilization and preference during the Second Grazing Period (n = 10). Trifolium repens was not included in the statistical analysis of stems (Kinsella, 1973).

1	1.000														
2	NS	1.000													
3	0.635*	NS	1.000												
4	NS	NS	NS	1.000											
5	NS	NS	NS	0.782**	1.000										
6	NS	NS	NS	NS	NS	1.000									
7	0.652*	NS	NS	NS	NS	NS	1.000								
8	NS	0.744*	0.690*	NS	NS	NS	NS	1.000							
9	NS	0.988**	NS	NS	NS	NS	NS	0.643*	1.000						
10	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.000					
11	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.733*	1.000				
12	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.816**	-0.897**	1.000			
13	NS	-0.722*	NS	NS	NS	NS	NS	NS	-0.774*	0.791*	NS	NS	1.000		
14	NS	NS	0.681*	NS	NS	NS	NS	0.675*	NS	NS	-0.761*	0.723*	NS	1.000	
15	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.791*	-0.781*	0.848**	0.696*	NS	1.000
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Pref.	Percent Prod.	Percent Util. Clipping	Percent Util. Fistula	Percent Util. Bite Count	Percent Moisture	Percent Leaves	Protein Prod.	Crude Fibre Prod.	Leaf Protein	Leaf Crude Fibre	Leaf A.P.D.M.D.	Stem Protein	Stem Crude Fibre	Stem A.P.D.M.D.

Pref. = Preference
Prod. = Production
Util. = Utilization
NS = Non Significant

TABLE 8. Correlation coefficient matrix for chemical and physical characteristics of the 10 forage species and animal utilization and preference during the Third Grazing Period (n = 10). Trifolium repens was not included in the statistical analysis of stems (Kinsella, 1973).

1	1.000														
2	NS	1.000													
3	0.850**	NS	1.000												
4	NS	NS	NS	1.000											
5	NS	NS	NS	0.844**	1.000										
6	0.740*	NS	0.634*	NS	NS	1.000									
7	NS	NS	NS	NS	NS	NS	1.000								
8	NS	0.751*	0.682*	NS	NS	NS	NS	1.000							
9	NS	0.994**	NS	NS	NS	NS	NS	0.690*	1.000						
10	NS	NS	NS	NS	NS	NS	NS	0.712*	NS	1.000					
11	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.726*	1.000				
12	NS	NS	NS	NS	NS	NS	NS	0.702*	NS	0.746*	-0.875**	1.000			
13	NS	NS	NS	NS	NS	NS	NS	0.680*	NS	0.938**	-0.696*	NS	1.000		
14	NS	NS	NS	NS	NS	0.791*	NS	NS	NS	NS	-0.827**	0.748*	NS	1.000	
15	NS	0.701*	0.715*	NS	NS	NS	-0.681*	0.723*	0.694*	NS	NS	NS	NS	NS	1.000
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Pref.	Percent Prod.	Percent Util. Clipping	Percent Util. Fistula	Percent Util. Bite Count	Percent Moisture	Percent Leaves	Protein Prod.	Crude Fibre Prod.	Leaf Protein	Leaf Crude Fibre	Leaf A.P.D.M.D.	Stem Protein	Stem Crude Fibre	Stem A.P.D.M.D.

Pref. = Preference
Prod. = Production
Util. = Utilization
NS = Non Significant

TABLE 9. Correlation coefficient matrix for chemical and physical characteristics of the 10 forage species and animal utilization and preference for the three grazing periods (n = 30). *Trifolium repens* was not included in the statistical analysis of stems (Kinsella, 1973).

1	1.000														
2	NS	1.000													
3	0.638**	0.581**	1.000												
4	NS	NS	NS	1.000											
5	NS	NS	NS	0.841**	1.000										
6	NS	-0.523**	NS	NS	NS	1.000									
7	0.362*	-0.433*	NS	NS	NS	0.493**	1.000								
8	NS	0.834**	0.734**	NS	NS	NS	NS	1.000							
9	NS	0.995**	0.533**	NS	NS	-0.548**	-0.467**	0.789**	1.000						
10	NS	-0.391*	NS	NS	NS	0.570**	NS	NS	-0.428*	1.000					
11	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.619**	1.000				
12	NS	NS	NS	NS	NS	0.579**	NS	NS	NS	0.788**	-0.814**	1.000			
13	NS	-0.646**	NS	NS	NS	0.608**	NS	NS	-0.680**	0.751**	-0.382*	0.522**	1.000		
14	NS	0.382*	NS	NS	NS	NS	NS	0.477*	0.397*	NS	-0.617**	NS	NS	1.000	
15	NS	NS	NS	NS	NS	0.445*	NS	NS	NS	0.668**	NS	0.648**	0.545**	NS	1.000
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Pref.	Percent Prod.	Percent Util. Clipping	Percent Util. Fistula	Percent Util. Bite Count	Percent Moisture	Percent Leaves	Protein Prod.	Crude Fibre Prod.	Leaf Protein	Leaf Crude Fibre	Leaf A.P.D.M.D.	Stem Protein	Stem Crude Fibre	Stem A.P.D.M.D.

Pref. = Preference
Prod. = Production
Util. = Utilization
NS = Non Significant

second grazing period, the steers preferentially grazed Russian wild ryegrass and birdsfoot trefoil and to a lesser degree, red top, alfalfa, white clover and the forage mixture. A strong avoidance was shown for crested wheatgrass and intermediate wheatgrass and a slight avoidance for creeping red fescue and sainfoin. Birdsfoot trefoil was the most preferred species in the third grazing period with some preference shown for red top, Russian wild ryegrass, white clover, alfalfa, bromegrass and the forage mixture. Crested wheatgrass, intermediate wheatgrass and creeping red fescue were strongly avoided and a slight avoidance was also shown for sainfoin. The preference rating was found to be correlated to utilization as determined by the clip method during the first ($r = 0.647$), second ($r = 0.635$) and third ($r = 0.850$) grazing periods (Tables 6, 7 and 8). The preference rating was not correlated to the fistula or bite count methods of determining utilization. The percent utilization of the individual species (Table 5) offered statistical evidence for many trends suggested by the preference rating (Table 4).

(b) Quality factors and chemical analysis of the forage species

A statistical analysis of percent leaves (Table 10) showed significant differences between species and grazing periods. White clover and Russian wild ryegrass were the leafiest species while crested wheatgrass had the least leaves. Percent leaves were negatively correlated ($r = -0.433$) to forage production when all seasons were analyzed collectively (Table 9).

The statistical analysis of percent moisture (Table 11) indicated significant differences occurred between the forage species and between the three grazing periods. Percent moisture was correlated

TABLE 10. Leaf dry weight for 10 forages during three grazing periods, expressed as a percent of the total plant dry weight (Kinsella, 1973).

Species[2/]	PERCENT LEAVES (n = 1) Grazing Period[1/] 1	2	3
Red Top	47	55	36
Crested Wheatgrass	35	20	25
Intermediate Wheatgrass	55	35	26
Bromegrass	43	44	24
Russian Wild Ryegrass	82	89	83
Creeping Red Fescue	37	38	50
Birdsfoot Trefoil	62	45	42
Alfalfa	55	51	44
Sainfoin	53	47	40
White Clover	--[3/]	--	--

1/ Grazing periods differ significantly at the 0.05 level with species as replications.

2/ Species differ significantly at the 0.01 level with grazing periods as replications.

3/ Stems were not separated from White Clover, however, observations indicate the percent leaf value would exceed other species.

TABLE 11. Moisture content for 10 forages during three grazing periods expressed as a percent of the total plant fresh weight (Kinsella, 1973).

Species[2/]	PERCENT MOISTURE (n = 1)		
	Grazing Period[1/]		
	1	2	3
Red Top	73	75	62
Crested Wheatgrass	71	62	54
Intermediate Wheatgrass	69	69	55
Bromegrass	76	67	54
Russian Wild Ryegrass	71	69	64
Creeping Red Fescue	66	68	57
Birdsfoot Trefoil	81	74	71
Alfalfa	78	73	66
Sainfoin	82	75	64
White Clover	79	78	69

1/ Grazing periods differ significantly at the 0.01 level with species as replications.

2/ Species differ significantly at the 0.01 level with grazing periods as replications.

(r = 0.634) to utilization as determined by the clip method during the third grazing period (Table 8).

All species with the exception of sainfoin leaves showed a significant reduction in percent crude protein over the three grazing periods (Table 12). Birdsfoot trefoil had the highest leaf crude protein level during the first grazing period with alfalfa and sainfoin having the highest level in the second period while alfalfa had the highest in the third period. Creeping red fescue had very low leaf crude protein levels during the three periods. During the first grazing period, crested wheatgrass, Russian wild ryegrass, creeping red fescue, birdsfoot trefoil and alfalfa had high stem crude protein levels while sainfoin was highest in the second and alfalfa was highest in the third period. Leaf crude protein was found to be negatively correlated (r = -0.653) to forage production in the first period (Table 6) and stem crude protein was negatively correlated (r = -0.722) to forage production in the second grazing period (Table 7).

During each grazing period, the kilograms protein produced per hectare (Table 13) showed a correlation to production and utilization as determined by the clip method (Tables 6, 7, 8 and 9). In the first period, protein production was highly correlated (Table 6) to utilization as determined by the fistula (r = 0.929) and bite count (r = 0.866) methods. Because of the close relationship between forage production and protein production, it was found that high yielding grasses (intermediate wheatgrass and creeping red fescue) produced the most protein per hectare during the first period and high producing, high protein legumes (alfalfa and white clover) produced the most protein per hectare in the third

TABLE 12. Percentage crude protein in leaves and stems analyzed from clipped samples of 10 forages during three grazing periods (Kinsella, 1973).

Species	LEAF PROTEIN (n = 2)			LSD[1/]		STEM PROTEIN (n = 2)			LSD	
	Grazing Periods			(0.05)	(0.01)	Grazing Periods			(0.05)	(0.01)
	1	2	3			1	2	3		
Red Top	21.6	16.3	16.1	1.7	4.0	11.1	9.9	7.4	1.7	4.0
Crested Wheatgrass	24.2	19.1	17.8	3.2	7.5	13.5	10.7	10.2	2.0	NS[2/]
Intermediate Wheatgrass	18.6	15.3	15.9	1.6	3.6	11.2	8.3	7.8	2.7	NS
Bromegrass	16.9	18.9	15.0	1.6	3.7	10.9	8.5	7.2	1.2	2.8
Russian Wild Ryegrass	23.0	21.8	16.5	0.2	0.4	14.9	12.1	8.3	2.0	4.6
Creeping Red Fescue	17.6	11.7	8.6	2.1	4.8	14.6	8.5	5.5	2.2	5.0
Birdsfoot Trefoil	28.0	19.6	19.8	3.2	7.4	14.5	10.9	9.2	1.5	3.6
Alfalfa	26.5	25.4	28.2	1.9	NS	13.9	10.5	11.9	2.0	NS
Sainfoin	26.0	26.5	22.8	NS	NS	11.4	13.7	9.8	0.3	0.7
White Clover	20.8	19.6	18.4	0.8	1.8	--[3/]	--	--		
LSD (0.05)	1.1	1.6	1.0			0.9	0.9	0.9		
LSD (0.01)	1.6	2.3	1.4			1.3	1.3	1.3		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non significant F value at the indicated level.

3/ White Clover stems were not analyzed.

TABLE 13. The production of crude protein per hectare based on the yield of the individual forage (Table 3), multiplied by the mean percent crude protein value (Table 11) for that species.

Species	PROTEIN PRODUCTION (kg/ha) (n = 4) Grazing Periods 1	2	3	LSD[1/] (0.05)	(0.01)
Red Top	203	551	671	206	311
Crested Wheatgrass	269	389	508	NS[2/]	NS
Intermediate Wheatgrass	436	665	568	NS	NS
Bromegrass	314	759	559	NS	NS
Russian Wild Ryegrass	139	164	239	NS	NS
Creeping Red Fescue	446	503	369	NS	NS
Birdsfoot Trefoil	190	779	593	NS	NS
Alfalfa	354	796	1,466	508	770
Sainfoin	314	658	626	NS	NS
White Clover	211	721	1,151	NS	NS
LSD (0.05)	154	311	490		
LSD (0.01)	NS	NS	661		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non significant F value at the indicated level.

grazing period. Red top and alfalfa both showed substantial increases in protein production over the entire experiment.

The stem crude fibre content of all species increased significantly between the first and third grazing periods (Table 14). The leaf crude fibre content, however, decreased between the first and third periods in six of the 10 forage species tested. Alfalfa had the lowest leaf crude fibre content of any species during each of the three periods. Red top had the highest percent leaf crude fibre during the first and third period, while creeping red fescue had the highest in the second period. Red top had the lowest stem crude fibre content during each period and sainfoin had the highest in the first period. Birdsfoot trefoil had the highest during the second and third grazing periods. A correlation ($r = 0.681$) was found between stem crude fibre and forage utilization as determined by the clip method during the second period (Table 7).

In the first grazing period, forage production and all methods of utilization determination were highly correlated with crude fibre production (Table 6). In the second and third periods, crude fibre production was correlated to forage production only (Tables 7 and 8). Due to the close relationship between crude fibre production and forage production, Russian wild ryegrass was low in crude fibre production (Table 15) in all three periods, although the difference was not significant in the third period. Creeping red fescue produced the most crude fibre per hectare in the first period, but not significantly more than intermediate wheatgrass or bromegrass. Intermediate wheatgrass produced significantly more crude fibre than most species during the second period. Red top, Russian wild ryegrass, creeping red fescue, birdsfoot

TABLE 14. Percentage crude fibre in leaves and stems analyzed from clipped samples of 10 forages during three grazing periods (Kinsella, 1973).

Species	LEAF CRUDE FIBRE (n = 2) Grazing Periods 1	2	3	LSD[1/] (0.05)	(0.01)	STEM CRUDE FIBRE (n = 2) Grazing Periods 1	2	3	LSD (0.05)	(0.01)
Red Top	38.2	32.4	36.3	0.3	0.8	29.4	38.9	39.4	0.8	1.9
Crested Wheatgrass	31.0	33.0	34.0	0.2	0.4	33.6	39.7	39.8	0.2	0.4
Intermediate Wheatgrass	34.8	34.0	33.7	0.3	0.6	32.1	44.6	41.5	0.4	1.0
Bromegrass	34.3	33.8	33.4	0.6	NS	37.8	44.3	39.6	0.1	0.1
Russian Wild Ryegrass	31.5	31.0	33.1	0.3	0.8	40.3	42.2	45.2	0.6	1.3
Creeping Red Fescue	34.0	34.6	32.5	0.3	0.6	36.0	44.5	45.6	0.4	1.0
Birdsfoot Trefoil	23.2	20.8	26.5	0.6	1.3	42.0	50.1	49.4	1.1	2.5
Alfalfa	22.6	19.7	22.2	0.5	1.1	42.4	49.7	47.6	0.1	0.2
Sainfoin	34.6	22.2	26.7	0.6	1.3	46.9	45.9	47.6	0.3	0.7
White Clover	27.9	33.7	36.0	1.3	3.0	--[2/]	--	--		
LSD (0.05)	0.4	0.6	0.1			0.1	0.5	0.3		
LSD (0.01)	0.6	0.8	0.2			0.2	0.7	0.4		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ White Clover stems were not analyzed.

TABLE 15. The production of crude fibre per hectare based on the yield of the individual forage (Table 3), multiplied by the mean percent crude fibre value (Table 13) for that species (Kinsella, 1973).

Species	CRUDE FIBRE PRODUCTION (kg/ha) (n = 4) Grazing Periods 1	2	3	LSD[1/] (0.05)	(0.01)
Red Top	362	1,439	2,423	685	1,037
Crested Wheatgrass	508	1,206	1,591	NS[2/]	NS
Intermediate Wheatgrass	960	2,506	2,273	NS	NS
Bromegrass	841	2,258	2,333	NS	NS
Russian Wild Ryegrass	212	255	559	271	NS
Creeping Red Fescue	1,017	2,087	2,020	814	NS
Birdsfoot Trefoil	251	1,938	1.731	1,339	NS
Alfalfa	527	1,513	2,794	929	1,406
Sainfoin	661	1,164	1,632	NS	NS
White Clover	286	1,236	2,257	1,504	NS
LSD (0.05)	293	764	NS		
LSD (0.01)	396	1,033	NS		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non significant F value at the indicated level.

trefoil, alfalfa and white clover had a significant increase in crude fibre production between the first and third grazing periods.

A.P.D.M.D. values (Table 16) declined over the three grazing periods with the exception of two species whose leaf values did not show a significant difference between the first and third periods and one species that showed an increase in stem A.P.D.M.D. over the same time. Alfalfa had the highest leaf A.P.D.M.D. values for all three periods with creeping red fescue being the lowest in the first period, intermediate wheatgrass being lowest in the second period and red top and intermediate wheatgrass being lowest during the third grazing period. Red top had the highest and Russian wild ryegrass the lowest stem A.P.D.M.D. value during the first grazing period. Alfalfa and sainfoin had the highest values in the second period and alfalfa was also highest in the third period. Intermediate wheatgrass had the lowest value in the second period and Russian wild ryegrass had the lowest in the third period. There was a positive correlation (Table 8) in the third grazing period between stem A.P.D.M.D. and forage production ($r = 0.701$) and utilization as determined by the clip method ($r = 0.715$).

(c) Grass-legume comparisons for the three grazing periods (Table 17)

The availability of forage did not differ significantly between the two groups (grasses and legumes). Availability of both was low during the first grazing period. The utilization of the grasses, as determined by the clip method, was higher than legumes during the first period, but utilization of legumes exceeded that of grasses in the second and third periods. The legumes had higher moisture, leaf protein, leaf

TABLE 16. Percentage digestible material in leaves and stems analyzed from clipped samples of 10 forages during three grazing periods (Kinsella, 1973).

Species	LEAF A.P.D.M.D.[2] (n = 2) Grazing Periods 1	2	3	LSD[1] (0.05)	(0.01)	STEM A.P.D.M.D. (n = 2) Grazing Periods 1	2	3	LSD (0.05)	(0.01)
Red Top	43.1	32.2	28.2	0.3	0.6	38.2	25.0	27.9	2.0	4.7
Crested Wheatgrass	40.5	35.7	31.2	1.1	2.5	34.1	28.0	25.9	4.0	NS[3]
Intermediate Wheatgrass	32.7	28.9	28.4	1.2	2.7	35.0	17.6	24.1	1.7	3.9
Bromegrass	34.9	35.0	35.0	NS	NS	27.0	23.5	29.0	1.2	2.8
Russian Wild Ryegrass	37.7	35.6	30.9	3.1	NS	23.5	23.0	17.2	1.1	2.4
Creeping Red Fescue	31.4	30.7	35.0	NS	NS	26.1	19.9	19.1	1.2	2.8
Birdsfoot Trefoil	55.1	47.0	42.8	1.1	2.5	36.5	28.1	27.7	0.7	1.6
Alfalfa	58.6	54.6	52.7	1.8	4.1	37.1	30.2	30.6	2.5	NS
Sainfoin	41.0	47.2	42.8	2.0	NS	30.6	30.2	26.9	0.4	0.9
White Clover	47.1	41.8	38.8	1.7	3.9	--[4]	--	--		
LSD (0.05)	0.7	1.2	0.8			0.8	0.6	1.3		
LSD (0.01)	1.0	1.7	1.2			1.1	0.9	1.9		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Acid-pepsin dry matter disappearance was used as an indicator of digestibility.

3/ Non-significant F value at the indicated level.

4/ White Clover stems were not analyzed.

TABLE 17. Grass (n = 6) and legume (n = 4) comparisons for various quality factors and physical characteristics (Kinsella, 1973).

		GRAZING PERIOD			LSD[1/]	
		1	2	3	(0.05)	(0.01)
Availability (kg/ha)	Grass	1,924.5	4,166.7	4,860.2	1,090.3	1,550.8
	Legume	1,293.3	4,160.3	5,615.0	1,709.0	2,528.4
Utilization[4/] (kg/ha)	Grass	954.5	1,359.2	1,075.3	NS	NS
	Legume	430.8*[2/]	2,797.5*	2,939.0*	1,460.2	2,160.3
% Leaves	Grass	49.8	46.8	40.7	NS	NS
	Legume	67.5	60.8	56.5	6.6	10.1
% Moisture	Grass	71.0	68.3	57.7	4.4	6.2
	Legume	80.0**[3/]	75.0*	74.2**	3.4	5.1
Leaf % Protein	Grass	20.3	17.2	15.0	2.4	3.5
	Legume	25.3*	22.3*	23.5*	NS	NS
Stem % Protein	Grass	12.7	9.7	7.7	1.7	2.4
	Legume	12.1	11.6	11.5*	NS	NS
Leaf % Digestibility	Grass	36.6	33.0	31.5	NS	NS
	Legume	50.5**	47.7**	44.3**	NS	NS
Stem % Digestibility	Grass	30.7	22.8	23.8	4.8	6.9
	Legume	32.6	29.2*	30.8	3.1	NS
Leaf % Crude Fibre	Grass	32.3	33.1	33.8	NS	NS
	Legume	27.0	24.2**	27.8*	NS	NS
Stem % Crude Fibre	Grass	34.8	42.3	41.8	5.2	7.4
	Legume	46.5*	46.8**	47.2**	NS	NS

1/ Least significant difference relates to grazing period comparisons.

2/ Indicates significant differences at the 0.05 level between the legume mean and the grass mean directly above determined by the unpaired t test.

3/ Same as 2/ only at the 0.01 level.

4/ Utilization as determined from clipped samples (Table 4).

digestibility (A.P.D.M.D.) and stem crude fibre values than the grasses in all three periods. Legumes also exceeded grasses in stem protein in the third period, stem digestibility in the second period and leaf crude fibre in the second and third grazing periods. Grasses had diminishing leaf and stem protein levels while legumes did not. Neither group showed a significant change in leaf digestibility and leaf crude fibre levels. Legumes had a reduction in percent leaves over the three periods.

2. Forage preference study using esophageal fistula collection technique

(a) Animal utilization of available forage

In the first grazing period, utilization as determined by esophageal fistula collections was highly correlated (Table 6) to utilization determined by the clip technique (r = 0.835) and forage production (r = 0.930). These correlations were not evident in the second and third periods (Tables 7 and 8).

A reduction in utilization was evident over the three periods for intermediate wheatgrass and bromegrass (Table 18). Intermediate wheatgrass and creeping red fescue were utilized more than other species during the first period with the exception of bromegrass and sainfoin of which differences were not significant. Creeping red fescue was also the most utilized forage, according to the fistula collection method, in periods two and three, but not significantly different from alfalfa in the third period.

(b) Chemical analysis of fistula sample as compared to calculated values

Fistula samples collected during the first and second grazing

Table 18. Percentage utilization (by frequency) of individual forage species by grazing steers based on the mean species composition of esophageal fistula samples (Kinsella, 1973).

Species	PERCENT UTILIZATION (n = 4) Grazing Period 1	2	3	LSD[1/] (0.05)	(0.01)
Red Top	5.4	7.7	8.0	NS[2/]	NS
Crested Wheatgrass	3.6	0.2	1.7	NS	NS
Intermediate Wheatgrass	18.9	5.2	9.6	8.2	NS
Bromegrass	13.4	16.9	4.9	6.7	NS
Russian Wild Ryegrass	1.2	6.6	6.0	NS	NS
Creeping Red Fescue	18.5	25.3	20.8	NS	NS
Birdsfoot Trefoil	6.0	3.7	1.2	NS	NS
Alfalfa	10.1	14.3	19.4	NS	NS
Sainfoin	12.7	10.4	5.6	NS	NS
White Clover	4.7	9.5	7.2	NS	NS
LSD (0.05)	6.4	9.9	8.8		
LSD (0.01)	8.7	13.3	11.9		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non-significant F value at the indicated level.

periods were higher in percent crude protein than those collected in the third period (Table 19). This relationship was also true of the calculated whole plant and stem values, while the leaf crude protein value did not vary significantly during the three periods. In the first grazing period, the crude protein level of the fistula sample was not significantly different from leaf and whole plant values, while being higher than the stem value. In the second period, the fistula crude protein value was higher than stem or whole plant values, but not significantly different from the leaf crude protein value. Fistula crude protein levels were similar to whole plant values, while being lower than leaf values and higher than stem values during the third grazing period.

In contrast to the fistula crude protein value, fistula crude fibre values (Table 20) were significantly different from the leaf value during each period. The fistula value increased significantly in the third period over the first and second periods. The leaf crude fibre value did not vary appreciably during the three periods, the stem value was high in the second period and the whole plant value was high in the second and third periods. Fistula samples and calculated stem values were higher in crude fibre than leaf and whole plant values during the first period. In the second period, fistula samples and whole plant values were higher than leaf crude fibre, but lower than stem crude fibre, while in the third period, the fistula samples were higher in crude fibre than leaf or whole plant values, but lower than the stem value.

The fistula samples decreased in A.P.D.M.D. (Table 21) each grazing period, while the calculated stem value declined only after the

TABLE 19. Percentage protein in esophageal fistula samples compared to calculated values based on percent protein from clip samples multiplied by percent composition of each species in fistula samples (Kinsella, 1973).

	PERCENT PROTEIN (n = 4)			LSD[1/]	
	Grazing Periods			(0.05)	(0.01)
	1	2	3		
Leaf	21.5	20.6	18.7	NS[2/]	NS
Stem	12.8	11.0	8.8	1.2	1.8
Whole Plant	18.2	16.2	13.1	3.1	NS
Fistula Sample	19.4	21.5	13.8	2.8	4.3
LSD (0.05)	1.7	2.2	1.3		
LSD (0.01)	2.5	3.1	1.9		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non-significant F value at the indicated level.

TABLE 20. Percentage crude fibre in esophageal fistula samples compared to calculated values based on percent crude fibre from clip samples multiplied by percent composition of each species in fistula samples (Kinsella, 1973).

	PERCENT CRUDE FIBRE (n = 4)			LSD[1]	
	Grazing Periods			(0.05)	(0.01)
	1	2	3		
Leaf	30.5	29.5	29.1	NS[2]	NS
Stem	37.4	49.8	45.7	9.0	NS
Whole Plant	32.4	39.0	38.3	5.4	NS
Fistula Sample	36.0	37.0	42.7	3.1	4.7
LSD (0.05)	3.3	5.2	2.1		
LSD (0.01)	4.8	7.5	3.0		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non-significant F value at the indicated level.

TABLE 21. Percentage A.P.D.M.D.[3/], of esophageal fistula samples compared to calculated values based on percent A.P.D.M.D. of clip samples multiplied by percent composition of each species in fistula samples (Kinsella, 1973).

	PERCENT A.P.D.M.D. (n = 4)			LSD[1/]	
	Grazing Periods			(0.05)	(0.01)
	1	2	3		
Leaf	41.1[3/]	44.0	40.8	NS[2/]	NS
Stem	32.8	27.4	25.4	5.4	NS
Whole Plant	38.4	36.2	32.6	NS	NS
Fistula Sample	32.6	24.6	16.8	4.6	7.0
LSD (0.05)	2.7	4.9	2.5		
LSD (0.01)	3.9	7.1	3.6		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non-significant F value at the indicated level.

3/ Acid-pepsin dry matter disappearance.

first period and leaf and whole plant values did not differ significantly during the three periods. In the first and second periods, fistula samples and the stem value was lower than leaf and whole plant values. In the third grazing period, the fistula samples had a lower A.P.D.M.D. value than all calculated values.

3. Forage preference study using the bite count technique

Utilization as determined by the bite count was closely related to the esophageal fistula data in each grazing period (Tables 6, 7, 8 and 9) and to forage production (r = 0.809) and clip data (r = 0.639) in the first grazing period.

The forage mixture increased in utilization between the first and third grazing periods (Table 22), while bromegrass decreased between the second and third periods and intermediate wheatgrass decreased between the first and second periods. In the first grazing period, intermediate wheatgrass, creeping red fescue and sainfoin appeared to be significantly more utilized than other species with the exception of bromegrass and alfalfa. Creeping red fescue was grazed more heavily than some species during the second period and the forage mixture was utilized more than most species in the third grazing period.

4. Statistical relationship between forage quality and the preference rating

Data was subject to analysis using the stepwise multiple regression program with Y being the preference rating. The equations generated by this program are listed in Table 23 for each grazing period. Partial regression coefficients were then considered in which the preference rating was the dependent variable and the independent variables

TABLE 22. Percentage utilization (by frequency) of individual forage species and a forage mixture by grazing steers based on bite count observations (Kinsella, 1973).

Species	PERCENT UTILIZATION (n = 4)			LSD[1/]	
	Grazing Period			(0.05)	(0.01)
	1	2	3		
Red Top	6.5	5.6	3.8	NS[2/]	NS
Crested Wheatgrass	3.5	0.3	2.3	NS	NS
Intermediate Wheatgrass	15.1	4.0	11.9	8.3	NS
Bromegrass	9.7	12.8	2.1	6.0	NS
Russian Wild Ryegrass	2.3	9.2	5.3	NS	NS
Creeping Red Fescue	14.8	16.4	11.3	NS	NS
Birdsfoot Trefoil	5.0	4.6	2.4	NS	NS
Alfalfa	9.8	6.4	12.6	NS	NS
Sainfoin	15.2	14.0	6.1	NS	NS
White Clover	6.2	13.7	7.9	NS	NS
Forage Mixture	6.5	13.2	18.7	9.0	NS
LSD (0.05)	6.0	9.8	8.5		
LSD (0.01)	8.0	NS	11.4		

1/ Least significant difference at the 0.05 and 0.01 levels.

2/ Non-significant F value at the indicated level.

TABLE 23. Regression equations illustrating the relationship between the preference rating (Y) and forage quality factors (Kinsella, 1973).

Grazing Period	Regression Equation
I	$Y = 1.645 - 0.029x_4$ $R^2 = 0.215$ (n = 9) Standard Error of Estimate: ±0.239
II	$Y = -4.214 + 0.037x_2 + 0.069x_8 + 0.120x_9 - 0.070x_4 - 0.117x_7$ $R^2 = 0.940$ (n = 9) Standard Error of Estimate: ±0.254
III	$Y = -2.415 + 0.155x_1 - 0.147x_8 + 0.009x_2$ $R^2 = 0.773$ (n = 9) Standard Error of Estimate: ±0.455
ALL	$Y = 3.304 + 0.023x_2 - 0.083x_5 + 0.063x_9 - 0.049x_6 - 0.064x_7$ $R^2 = 0.442$ (n = 27) Standard Error of Estimate: ±0.469

x_1 Percent Moisture
x_2 Percent Leaves
x_3 Heading Date and Plant Height
x_4 Leaf Protein
x_5 Leaf Crude Fibre
x_6 Leaf A.P.D.M.D.
x_7 Stem Protein
x_8 Stem Crude Fibre
x_9 Stem A.P.D.M.D.

were introduced into the regression equation by the computer program for each grazing period in the order shown in Table 24. In the first grazing period, we were unable to produce a significant regression equation. During the second period, percent leaves, stem crude fibre content and stem A.P.D.M.D. had the greatest influence on the preference rating, while percent moisture had the greatest effect in the third period. When all grazing periods were analyzed collectively, percent leaves, leaf crude fibre and stem A.P.D.M.D. had a significant effect on the preference rating.

B. Grazing Behaviour Patterns Exhibited By Six Esophageal Fistulated Steers

When the mean species composition of fistula samples was compared, bromegrass and creeping red fescue were utilized more than other species with the exception of red top (Table 25). Sainfoin and Russian wild ryegrass were not utilized by four of the steers, while two steers avoided red top and white clover. Interesting differences in individual animal grazing behaviour were illustrated, but we were unable to produce statistical evidence of the significance of these differences.

C. Confined Animal Preference Study

The statistical analysis of Table 26 produced no significant differences between bromegrass and alfalfa or any differences between group number one and group number two.

TABLE 24. Standard partial regression coefficients obtained from the stepwise multiple regression analysis of forage quality factors when Y was the preference rating (Kinsella, 1973).

	Character	Partial Regression Coefficient
GRAZING PERIOD I (n = 9)	Leaf Protein	-0.464 NS
	Intercept	1.645
GRAZING PERIOD II (n = 9)	Percent Leaves	1.073 **
	Stem Crude Fibre	0.421 *
	Stem A.P.D.M.D.	0.846 *
	Leaf Protein	-0.523 NS
	Stem Protein	-0.335 NS
	Intercept	-4.214
GRAZING PERIOD III (n = 9)	Percent Moisture	1.247 **
	Stem Crude Fibre	-0.764 NS
	Percent Leaves	0.209 NS
	Intercept	-2.415
ALL GRAZING PERIODS (n = 27)	Percent Leaves	0.691 **
	Leaf Crude Fibre	-0.789 **
	Stem A.P.D.M.D.	0.628 *
	Leaf A.P.D.M.D.	-0.761 NS
	Stem Protein	-0.283 NS
	Intercept	3.304

* Significant at the 0.05 level.

** Significant at the 0.01 level.

TABLE 25. Percent composition of esophageal fistula samples collected from six individual steers grazed in pairs (Kinsella, 1973).

SPECIES	PERCENT COMPOSITION (n = 5)						MEAN
STEER NO.:	1	2	3	4	5	6	
PAIR NO.:	I		II		III		
Red Top	--	25.3	34.5	19.4	--	9.9	14.9
Crested Wheatgrass	21.7	3.2	2.6	2.1	--	1.3	5.1
Intermediate Wheatgrass	11.1	2.5	1.6	16.0	7.0	4.8	7.2
Bromegrass	39.6	33.3	38.7	19.1	9.7	17.0	26.2
Russian Wild Ryegrass	--	--	--	--	1.2	1.9	0.5
Creeping Red Fescue	15.6	29.7	7.5	19.3	27.5	42.6	23.7
Birdsfoot Trefoil	1.4	4.2	1.3	1.3	17.2	0.7	4.4
Alfalfa	10.6	0.3	4.2	15.8	--	18.1	8.2
Sainfoin	--	--	--	7.0	--	0.8	1.3
White Clover	--	1.5	9.6	--	37.4	2.9	8.6
					LSD	0.05[1/]	11.82
					LSD	0.01	15.82

[1/] Least significant difference of the mean at the 0.05 and 0.01 levels.

TABLE 26. Kilograms of fresh-cut Bromegrass and Alfalfa consumed by confined steers (Parkland Farm, University of Alberta, 1973).

	Day	SPECIES UTILIZATION (kg)[1/] (n = 1)	
		Bromegrass	Alfalfa
GROUP I			
	1	13.85	15.35
	2	9.35	15.05
	3	18.20	13.60
	4	19.10	19.95
GROUP II			
	1	9.85	19.35
	2	8.95	11.50
	3	12.95	13.25
	4	17.50	18.90
MEAN			
		13.72	15.87

[1/] Differences between species and groups were not significantly different.

DISCUSSION

A. Species Composition

Red top, which is no longer recommended as a pasture crop in the Province, was found to be a poor producer during the early part of the grazing season (Table 3). The animals did show preference for this species in the third period (Table 4), possibly because of its succulence, leafiness and high stem quality. This could have been a result of its late maturing characteristic.

The animals did not show a preference for crested wheatgrass during the first Kinsella grazing trial (Table 4) because of low moisture content, steminess and early maturity as compared to other species. It was a high protein forage throughout the trial and had palatable stems. Crested wheatgrass was best adapted to low moisture growing conditions (Lodge _et_. _al_., 1972; Mercer, 1938). It would not be recommended for use in this high rainfall area, where higher producing species were easily established.

Intermediate wheatgrass was the highest producing single species (Table 3). It was a rapid growing, late maturing forage, but was relatively low in protein. Lawrence _et_. _al_. (1971), recommended that it be chosen in preference to bromegrass or reed canarygrass (_Phalaris arundinacea_ L.) for use under irrigated conditions, because of its high dry matter yield.

Bromegrass is the most common tame perennial forage grass

grown in the Province because of its wide adaptability. It produced slightly less than intermediate wheatgrass during the trial (Table 3), but was the most utilized of all grasses, according to the clip data (Table 4), possibly due to highly palatable stems. The second Kinsella grazing study (Table 25), using six fistulated animals, showed bromegrass to be the most preferred forage species, however, the explanation for this selectivity was not apparent.

The most preferred grass based on the preference rating (Table 4) was Russian wild ryegrass, which was attributed to its high percentage of leaves and moisture. Unfortunately, this species was very slow to establish and produced the least dry matter of any forage in this study (Table 3). Once established, however, it reportedly out-yielded bromegrass and crested wheatgrass in the brown soil zone (Lawrence and Heinrichs, 1966). These workers also found Russian wild ryegrass to be comparatively high in protein, especially during fall and winter, which agreed with the findings in this study.

Creeping red fescue was the least utilized species, according to the clip data (Table 4) and the most utilized species, according to the fistula (Table 18) and bite count method (Table 22). One explanation for this discrepancy could be that the steers were readily attracted to the creeping red fescue when first turned into the pasture because of its dark green colour. This would give high readings for fistula and bite count methods. The animals may have very soon tired of this species and avoided it in favour of more palatable species which would give a low value for the clip method of evaluating utilization. The protein content was very low (Table 12) which could be partially due to the absence of

nitrogen fertilizer. This could have caused animal avoidance of this species. Creeping red fescue was the earliest maturing species, which explained the significant reduction in preference (clip data) after the second grazing period.

The steers showed a preference for birdsfoot trefoil in the second and third periods, as illustrated by the preference rating (Table 4). Clip data (Table 4) showed it to be the most utilized legume over the three periods, however, the bite count (Table 22) and fistula data (Table 18) suggested that it was the poorest utilized legume. One explanation for this discrepancy was that the animals did not readily graze this species when first turned in a pasture, as was the case when sampling the animals, but when allowed a longer grazing time, they discovered and utilized birdsfoot trefoil to a great extent. Only the leaves and uppermost stem portions were grazed as the stems became extremely wiry and unpalatable. The leaves were succulent and of high quality. Crampton (1957) showed high relative gain on sheep grazing this species and high daily intake of birdsfoot trefoil as compared to other forages under study.

Because of its high production and excellent quality, alfalfa is the most widely grown legume in the Province. In this study, it averaged 26.7 percent leaf protein (Table 12) and had the highest percent digestibility (Table 16). It flowered later than other legumes and because of its delayed maturity, it was highly utilized in the second and third periods (Table 4). The fistula method (Table 18) shows alfalfa to be the most utilized legume, however, clip data (Table 4) suggested that some of the alfalfa recovered in the fistula sample was obtained from the forage

mixture.

Sainfoin was relatively high yielding during the first period, but was the lowest yielding legume in the second and third periods (Table 3). Hanna et. al. (1972), reported sainfoin yields to be 85 percent of alfalfa. The clip data (Table 4) indicated poor utilization as compared to other legumes, however, other data (Tables 18 and 22) showed much greater utilization of this species. The animals were very selective in grazing leaves of this forage while leaving stems untouched possibly due to the coarseness of the stems. Sainfoin was not readily accepted by the steers and it took approximately one month for them to develop a taste for this species. It was high in protein (Table 12) but less than alfalfa, which agreed with other workers (Ditterline and Cooper, 1975; Hironaka and Hanna, 1975).

White clover was a low yielding forage in the first period, but due to the high precipitation later in the season, increased production in the second and third periods (Table 3). A Montana study reported poor forage yields with white clover compared to other legumes (Cooper et. al., 1971). It was poorly utilized (Tables 4, 18 and 22) during the first period, largely due to lower availability. A discrepancy existed between the methods of data collection in that the clip data indicated high utilization and preference in the third period, where the bite count and fistula methods showed higher utilization in the second period. Extremely high production (Table 3) and utilization was observed when this species was grown in low, wet areas during the third period. The general quality of this forage appeared lower than other legumes, possibly due to the large petioles included in the leaf analysis.

The preference shown for the forage mixture (Table 4) suggested that grazing animals were attracted to a heterogenous plant community (Jones, 1952). High production values (Table 3) for the mixture may be attributed to the effect the nitrogen fixing legume had on grass yields. Due to the variation in animal preference, forage mixtures were considered superior to pure stands because the individual animals were given a choice of forage which allowed them to adjust their diet to satisfy their nutritional needs. Creeping red fescue was poorly utilized in pure stands in the third period (Table 4), however, it was the most abundant forage encountered in the esophageal fistula samples (Table 18). This suggested the animals preferred creeping red fescue when grown in a mixture. The bite count method (Table 22) illustrated the increase in forage mixture utilization, possibly because the mixture appeared more succulent than single species due to the very dense growth.

B. Quality Analysis

The forages tested were common Alberta pasture species, any one of which would be readily utilized by cattle if no alternatives were offered. Minor variations in utilization, as were obtained during the first grazing period, were of little practical significance because they probably would not affect animal intake. Wide variations in individual animal grazing behaviour nullified the importance of small differences in animal preference. Many workers (Coleman and Barth, 1973; Fontenot and Blaser, 1965; Hardison _et_. _al_., 1954; Weir and Torell, 1959; Rama Rao _et_. _al_., 1973) have shown that grazing animals tend to select a diet which is higher in crude protein, more digestible and lower in crude fibre, when offered a variety of forage. In this study, it was difficult to isolate

the effect of any one quality factor on the selective grazing behaviour of steers as illustrated by the poor correlation between utilization and the various quality components (Tables 6, 7, 8 and 9). Other workers (Crampton, 1957; Dubbs, 1966; Meyer et. al., 1957; Milford and Minson, 1966; Tribe, 1952; Van Soest, 1964) have also reported poor correlations between preference or intake and the nutritional value of forages. Crampton (1957) indicated as long as the animal's basic nutritional needs were satisfied, little selection was likely to occur. In other studies, a close relationship was observed between preference or intake and nutritive forage value (Blaxter, et. al., 1961; Blaser et. al., 1960; Cook, 1959; Plice, 1952). Results of this study indicate that the various quality components may have a cummulative influence on animal preference as suggested by the relationship between protein, digestibility and crude fibre (Tables 6, 7, 8, and 9). It was also suspected that quality components have a maximum or minimum level, which when exceeded, results in avoidance for that particular forage species. Forage utilization studies are further complicated by the fact that most chemical constituents are highly species oriented and high correlations may exist within one species which are found to be unrelated in another species (Van Soest, 1965). When grasses and legumes were compared in the same trial, the legumes were usually of higher chemical quality and different physical growth habit than the grasses (Table 17).

It is generally accepted that the degree of selection is directly related to the abundance of forage. In this trial, utilization was highly correlated to the production of individual species in the first grazing period (Table 6). This relationship was not evident when

forage species matured and it was assumed that forage production exerted an influence on animal selectivity when all species were of high quality, but became less important as forage quality declined.

Percent leaves has long been considered an indicator of nutritive quality because grazing animals usually select the leafy portions of forage. It has recently been shown that leaf percentage is not a reliable criteria for judging forage quality, due to the wide variations in the chemical composition of grass stems which would affect the overall acceptance of a forage by a grazing animal (Mowat et. al., 1965; Pritchard et. al., 1963). Dubbs (1966) reported on the willingness of cattle to graze the stems of palatable grass species, which may account for the high utilization (Table 4) of red top during the third grazing period. In the second and third grazing periods, the cattle carefully removed the leaves from sainfoin without removing any stem portion. Percent leaves (Table 10) appeared to be very species oriented in its relationship with utilization, as indicated by the poor correlation during the grazing periods (Tables 6, 7 and 8). This factor had a significant influence on the preference rating in the second grazing period and when all periods were analyzed collectively (Table 23).

Moisture content of forage is seldom mentioned as a factor in forage preference, however, in this study, percent moisture (Table 11) was correlated to utilization as determined by the clip method during the third grazing period (Table 8) and was a significant component of the preference rating (Table 23) in the third grazing period. Hilton and Bailey (1972) also reported moisture content as being an important factor affecting animal preference of native forage species. It was

suspected that there may be an optimum forage moisture range affecting animal preference, as legumes above 78 percent moisture were avoided as well as grass species below 60 percent (Table 17). Admittedly, factors other than moisture influenced this avoidance behaviour. The higher moisture content (Table 11) of red top, Russian wild ryegrass, birdsfoot trefoil and white clover could partially account for their high utilization in the third grazing period (Table 4).

Crude protein was not correlated (Tables 6, 7, 8 and 9) to utilization in any grazing period. The explanation could be that the leaf crude protein of the species (Table 12) included in this study was always above the 8.5 percent minimum, as reported by Blaxter and Wilson (1963). Protein levels above this minimum limit would be adequate to satisfy the animals' nutritional requirements and would not correlate to utilization (Milford and Minson, 1966; Dubbs, 1966). Leaf protein exerted a significant influence on the preference rating as shown by the partial regression coefficients in the second grazing period (Table 24). Low protein (Table 12) could account for the poor utilization of creeping red fescue in the third grazing period. Protein production (Table 13) per hectare was correlated to utilization (Tables 6, 7, 8 and 9) determined by the clip method during each grazing period, which suggested that the grazing animal preferred high producing, high quality forage. The steers selected a diet higher in protein than the calculated whole plant protein value (Table 19), indicating a preference for leaves over stems.

Forage crude fibre content appeared to be a species oriented factor as leaf crude fibre was not correlated to utilization and stem crude fibre was only related in the second period (Table 7), probably due to the preference shown for legumes. Leaf crude fibre was a signifi-

cant component of the preference rating when all grazing periods were analyzed collectively (Table 23) and stem crude fibre had a positive effect on the rating in the second period. This study did not show a lower crude fibre content in fistula samples as compared to available forage (Table 20), due to the loss of soluble material from the fistula collection bag. This resulted in crude fibre values 15 to 20 percent higher than expected. The higher degree of leaf selectivity observed when cattle grazed legumes could be attributed to the greater difference between leaf and stem crude fibre in legumes, compared to grasses (Table 17). Crude fibre production (Table 15) was only correlated to utilization during the first grazing period (Table 6) probably due to the influence of availability rather than the crude fibre content.

Crampton (1957) and Van Soest (1965) reported poor or variable correlations between forage digestibility and animal intake, which, with the exception of stem A.P.D.M.D. in the third grazing period (Table 8), agrees with the findings of this study. Species variability could again be the cause of this poor relationship.

C. Methods of Evaluating Forage Preference

Of the three utilization techniques employed in this study, the clip method was considered less subject to animal sampling error and more representative of the animals' grazing habits over extended periods of time. This method gave a quantitative evaluation of grazing preference (Table 4), however, these values may have been overestimated due to trampling of forage in the grazed area (Laycock, Buchanan and Krueger, 1972; Reynolds and Packer, 1962). The clip method had a greater labour re-

quirement because of the large number of samples collected and analyzed as well as the construction of exclosures. High plot variation was a result of uneven animal distribution and variable plant growth habits within each pasture (Table 3). Plant growth within each grazing period was masked by the plot variability. The low correlation (Tables 7, 8 and 9) between the clip method and the other preference evaluation methods was attributed to the difference between the two methods of expressing utilization (dry-weight versus frequency) and the difference in time and frequency of data collection (once per grazing period as opposed to three times per week).

The use of esophageal fistulated steers was the least desirable method of evaluating forage preference in this particular grazing study. The animals were under noticeable stress when sampling and this affected their grazing habits. Sometimes a steer would refuse to graze at all when the stoppers were removed, while in other instances, the steer would "wolf" down forage in an unselective manner. This behaviour was attributed to the high degree of handling and the period of confinement prior to sampling, the cumbersome apparatus placed on the animal for collection purposes and the development of esophageal ulcerations in varying severity among the animals. The stress factor had not been reported as a problem by other workers.

The esophageal ulcerations were partially caused by the material used in the manufacture of the split-plug stoppers, with pure rubber causing the greatest problem and clear plastisol and Flexane causing less difficulty. The tendency of the fistulas to cause compaction in the esophagus when the animals were grazing coarse forage probably aggravated

the ulcerations and contributed to the overall poor condition of the steers. Animals require close observation when grazing forage with the stoppers replaced in the esophagus. Bath _et_. _al_. (1956), reported, "the most difficult task in connection with this procedure was keeping the fistulated sheep in good health and condition to make the collections". This statement would possibly be equally applicable to cattle.

Sampling time was limited to 15 or 20 minute periods as difficulty replacing the stoppers was experienced due to the constriction of the fistula, if longer collection periods were attempted. This problem may be overcome by the use of a permanent cannula in the fistula, however, this would result in poorer forage recovery (Lesperance _et_. _al_., 1960; Campbell _et_. _al_., 1968; Barth _et_. _al_., 1971). In this study, incomplete collections were observed. Coarse material grazed was not present in the collection bag. Fine leaved, densely tufted species were overestimated as each bite contained many leaves which passed readily through the fistula. If possible, plants under study should be of similar growth habits and physical characteristics. Bias was also encountered in species identification. The legumes and two grasses were easily identified whereas the remaining four grasses were more difficult. Only the careful study of an undamaged specimen would yield a reliable identification. Heady and Torell (1959) reported similar problems when they attempted to analyze grass material in the vegetative stage collected from fistulated sheep. This problem could also be overcome by selecting easily distinguishable forage species.

Problems were encountered with the chemical analysis, caused by the loss of certain soluble components of the fistula sample, which were

observed draining from the screen bottom in the collection bag. This leaching of soluble carbohydrates (Table 20) coupled with high drying temperatures (Van Soest, 1964), increased the crude fibre values, while lowering the A.P.D.M.D. values (Table 21). Coleman and Barth (1973) adjusted the acid-detergent fibre values to account for the loss of soluble material. Collection bags, that do not allow any draining of saliva or soluble material, could be used to retain the soluble portion for chemical analysis, however, the presence of saliva in a sample greatly hindered species identification.

Workers have found the esophageal fistula method to be a useful sampling technique for forage evaluation under native rangeland conditions (Bath et. al., 1956; Edlefsen et. al., 1960; Van Dyne and Torell, 1964). This method appeared poorly suited to the evaluation of tame pasture species of similar appearance grown in discrete plots.

The bite count method of determining forage preference of grazing animals was found to be simple and descriptive of animal behaviour (Table 22). The bite count was only conducted while the animals were actively collecting with the esophageal fistulas, however, the observation time could be extended to any length desired with no adverse effect on the animals. This method reduced within plot variation, while providing a large number of replications using animals and time. It was sometimes difficult to see the animals in the tall forage, but a centrally-located observation tower used in conjunction with field glasses would overcome this problem. Cultivated strips around each plot would also aid in observing utilization of individual species. Free (1969) reported that the bite count and microscope method of examining

fistula samples produced comparable estimates of composition in the diets of steers for certain native grasses and forbs. This agreed with the finding in this study (Tables 6, 7, 8 and 9).

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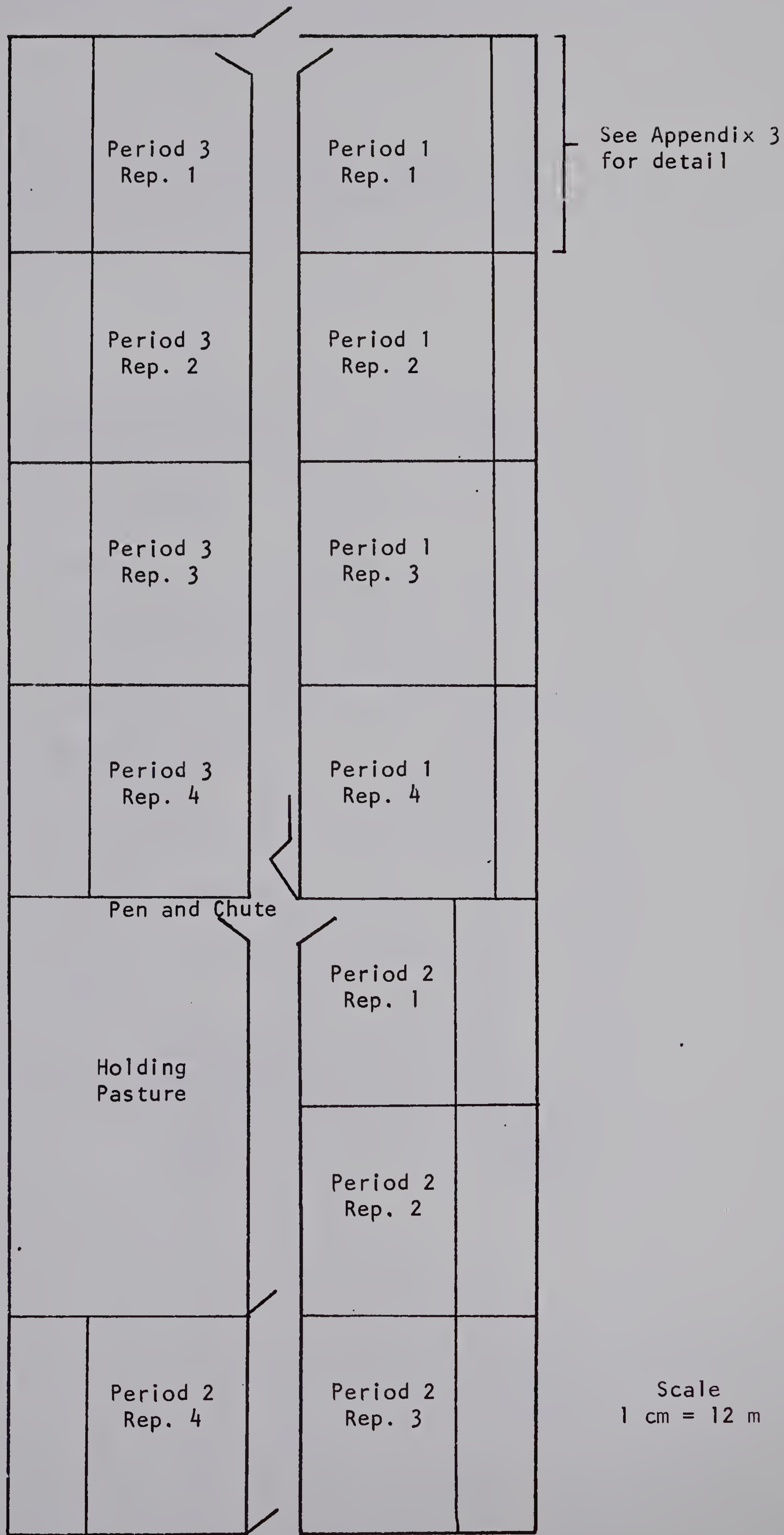
APPENDIX 1

Plant height on July 18, 1973, and approximate heading and flowering dates of the 10 forage species.

Species	Plant Height (cm)	Heading and Flowering Dates
Red Top	78.7	June 25th - 29th
Crested Wheatgrass	81.3	June 11th - 15th
Intermediate Wheatgrass	127.0	June 25th - 29th
Bromegrass	111.8	June 18th - 22nd
Russian Wild Ryegrass	101.6 (50.8 Leaf Ht.)	June 18th - 22nd
Creeping Red Fescue	71.1 (45.7 Leaf Ht.)	June 4th - 8th
Birdsfoot Trefoil	55.9	June 25th - 29th
Alfalfa	76.2	Mid August
Sainfoin	88.9	June 18th - 22nd
White Clover	30.5	June 11th - 15th

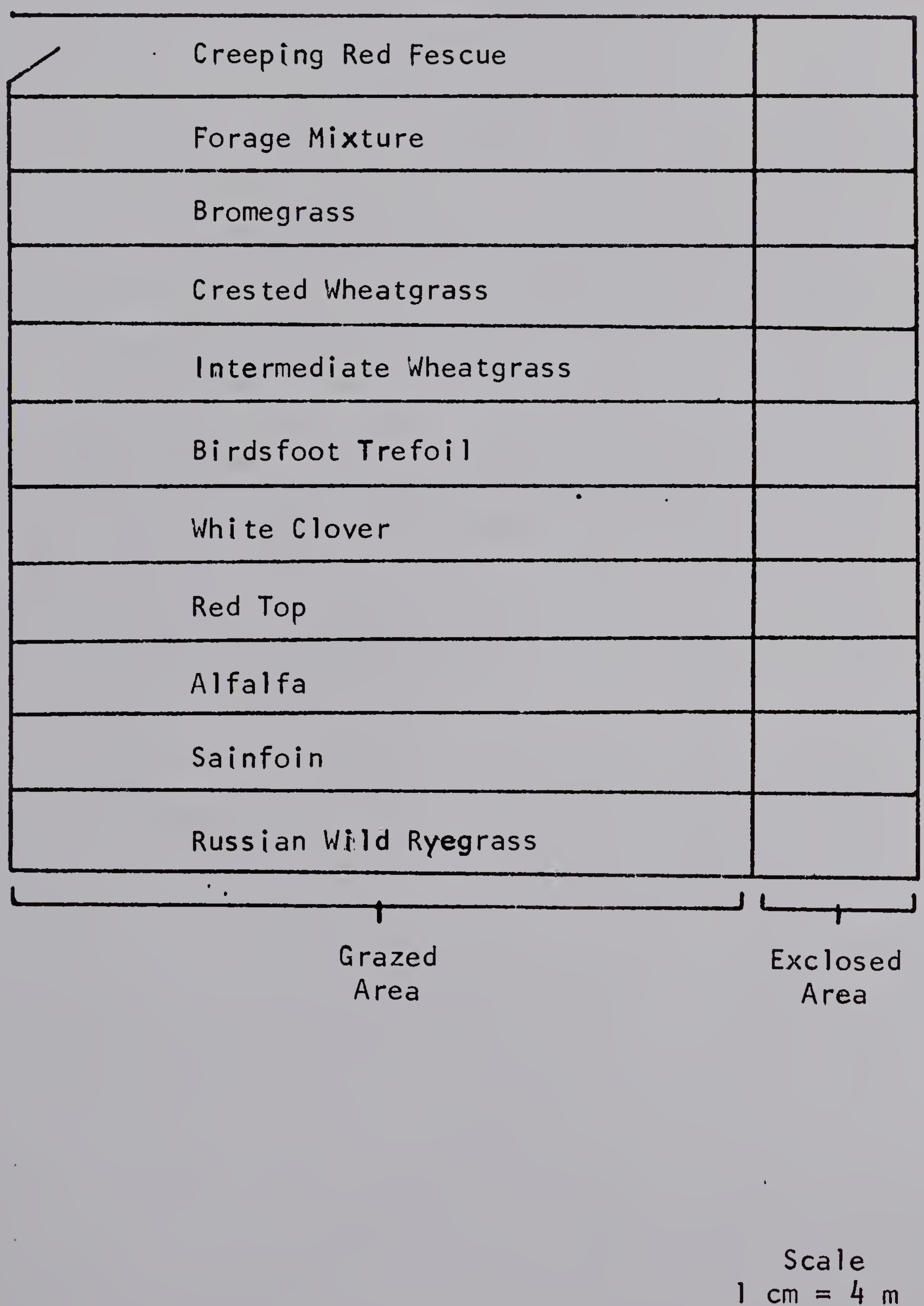
APPENDIX 2

Plot plan of study area. (See Figure 1)



APPENDIX 3

Plot plan of replication 1 for the first grazing period. Other replications for all grazing periods were similar but with species in random order. (See Figure 1).



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